Bol. Soc. Paran. Mat.
©SPM –ISSN-2175-1188 on line
SPM: www.spm.uem.br/bspm

(3s.) **v. 2023 (41)** : 1–7.
ISSN-0037-8712 in press
doi:10.5269/bspm.52209

Comparison of C, Java, Python and Matlab Programming Languages for Fibonacci and Towers of Hanoi Algorithm Applications

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ABSTRACT: Many programming languages evolved with the development of technology. However, it is still not clear which programming language should be used for which applications since there are not enough comparisons of these languages. The aim of this study is to compare the performances of some of the most frequently used programming languages; C, Java, Python and Matlab for Fibonacci and Towers of Hanoi algorithm applications. These algorithms are chosen for this study because they are both recursive algorithms and are widely used in computer science. Performances of these languages are measured according to the code length, programming effort, runtime efficiency and reliability. The results obtained are shown in this study.

Key Words: Programming languages, C, Java, Matlab, Python, Fibonacci, Towers of Hanoi.

Contents

1. Introduction

The development of technology also affected the progress of the programming languages. Programming languages have evolved very quickly since 1950s, many different languages were invented and still being invented even today [1]. In order to develop more efficient and effective programs, it is important to find out which programming language is suitable to which situation [2]. Some languages become popular from time to time and this causes developers to use that popular language for every software application they develop although they are not sure it is suitable or not [3]. This situation affects other programming languages since using another language may be more suitable for the intended software application.

Performance and speed gain more importance each day since the developing technology and big data may require to work several different softwares at the same time. From the moment we turn on our computer, some softwares are always running in the background loading the operating system and carrying out different instructions [2]. For this reason, it is important to measure the performances of the programming languages. In this study, 4 programming languages (C, Java, Python and Matlab) will be compared. C and Java are conventional and high-level mainstream languages. Python and Matlab are popular scripting languages widely accepted by authorities and frequently used by developers. Python is especially popular because it is an object-oriented language and also supports open source environment [4].

These languages are compared for Fibonacci and Towers of Hanoi algorithm application in Windows environment. The reason why these are chosen for this study is that recursion is an important problem solving and programming technique for computer science [5]. Also, both algorithms are covered in computer science courses. Fibonacci algorithm gives a base case then allows a program to make repeated calls to a method to solve the problem. The Fibonacci Numbers are defined by the recursive relation defined by the equation below.

2010 *Mathematics Subject Classification:* 35B40, 35L70.
Submitted February 15, 2020. Published October 19, 2020

$$F_n = F_{n-1} + F_{n-2}, \text{for all } n \geq 3 \text{ where } F_1 = F_2 = 1 \tag{1.1}$$

Fibonacci Equation

In the equation 1 above, F_n represents the n^{th} Fibonacci number (n is called an index). The Fibonacci sequence can elaborately be written as $\{1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, \ldots\}$ [6]. Fibonacci numbers also exist in nature and they are associated with the Golden Ratio.

The Towers of Hanoi consists of 3 pegs and n different sizes of rings each on top of each other and resting on these pegs. The goal here is to move the n rings to another peg in such a way that the bigger ring cannot placed on top of the small ring [7]. In order to solve this problem, first, it is necessary to calculate how many moves are needed for n number of rings. Therefore, $2^n - 1$ formula is used to find out the minimum number of moves needed to move n disks to another peg. Afterwards, the algorithm given in Table 1 is used to solve the rest of the problem.

Table 1: Towers of Hanoi algorithm

```
tower(disk, source, inter, dest)

IF disk is equal 1, THEN
move disk from source to destination
ELSE
tower(disk - 1, source, destination, intermediate) // Step 1
move disk from source to destination               // Step 2
tower(disk - 1, intermediate, destination, source) // Step 3
END IF

END
```

When a recursive program is being executed, it establishes a stack to use while passing through the tree. However, a great deal of duplication work may occur, if the results stored in the stack are discarded rather than kept in some other data structure for prospective use such as in the case of calculating Fibonacci numbers and Towers of Hanoi [8]. Therefore, these algorithms may consume a lot of memory and take a lot of time to run unless executed with the right programming language. That is why it is important to know the performances of the programming languages.

Performance comparisons of programming languages are realized before in several other studies. Prechelt made an empirical study in 2000 comparing seven programming languages [9] and Hu et. al. made a study in 2000 comparing Java, Fortran and C for numerical computing [10]. Biswa et. al. made a similar study in 2016 also adding C# into the picture and comparing Java, Fortran, C and C# programming languages [2]. Sahin made a study in 2007 by adding scripting languages and compared Java, Python and Ruby programming languages [11]. However, none of the studies used a recursive algorithm to make the comparisons. This study will use Fibonacci and Towers of Hanoi algorithms for the comparison. Several different aspects will be investigated such as code length, programming effort, runtime efficiency and reliability. The next section will explain the test environment and mention the results of the tests performed.

2. Method

In this paper, four programming languages C, Java, Matlab and Python are compared for Fibonacci and Towers of Hanoi algorithm applications in terms of runtime, code length and character length. 1,000,000 is chosen as the input number to execute the Fibonacci algorithm. The algorithm has been executed 5 times in each language and the average of these executions are used for results. The algorithm for Fibonacci can be seen in Table 2.

Table 2: Fibonacci algorithm

```
def fibonacci(n)
last_two_numbers = [ ]
fibo_number = 1
n.times do | counte |
if counter > 1
fibo_number = last_two_numbers[0] + last_two_numbers[1]
end
last_two_numbers = [last_two_numbers[1] ,fibo_number]
end
```

The algorithm for Towers of Hanoi is mentioned in Table 1 above. 20 is chosen as the number of disks to execute this algorithm. This algorithm also has been executed 5 times in each language and the average of these executions are used for results. The test platforms and the execution times are shown below.

2.1. Test Platform

All the tests are run for C, Java, Python and Matlab on Windows 10 operating system. The below computer is used to execute the tests for all programming languages.

- Windows 10 Pro for Workstation
- Intel(R) Core(TM) i7-7700 HQ CPU @ 2.80GHz 2.81 GHz
- Memory(RAM):16.0 GB
- System Type:64 bit Operating System,x64 based processor
- Compilers:
  - C: CodeBlocks 17.12
    - There are many IDE platforms for compiling C language but for this study, CodeBlock is preferred since it is one of the most commonly used platforms.
  - Java: NetBeans 8.0.2
    - The most widely used Java IDE platforms are NetBeans and Eclipse. In this study, NetBeans is preferred over Eclipse because NetBeans is easier to use and has more features. Although Eclipse can handle larger projects, this study includes only 2 algorithms to run so it is not a very large project.
  - Matlab: Matlab R2018a (9.4.0.813654)
    - Matlab IDE is the original IDE platform provided by Mathworks. Therefore, Matlab IDE is preferred in this study.
  - Python: Python 3.7.4

2.2. Execution Times

Fibonacci algorithm was run 5 times for Matlab, C and Java languages on Windows operating system. After the executions, the average results were used. The results for the run times are shown in Table 3 in seconds.

Table 3: Execution times of programming languages (seconds)

Test Number	MATLAB	C	JAVA	PYTHON
1	0.0306	56.098	19	12.036
2	0.0348	54.725	15	11.650
3	0.0274	54.118	18	11.508
4	0.0213	53.977	13	11.496
5	0.0349	54.961	12	11.500
Average	0.029790	54.7758	15.4	11.638

It can be seen from the above results that the fastest runtime for Fibonacci algorithm is achieved with Matlab programming language with an average of 0.029790 s. The worst performance among these languages belong to C with an average of 54.7758 s. The below Figure 1 gives a better understanding of the runtime differences between programming languages. While there is a vast amount of difference between Matlab and C, Java and Phyton are very close to each other in terms of execution performances.

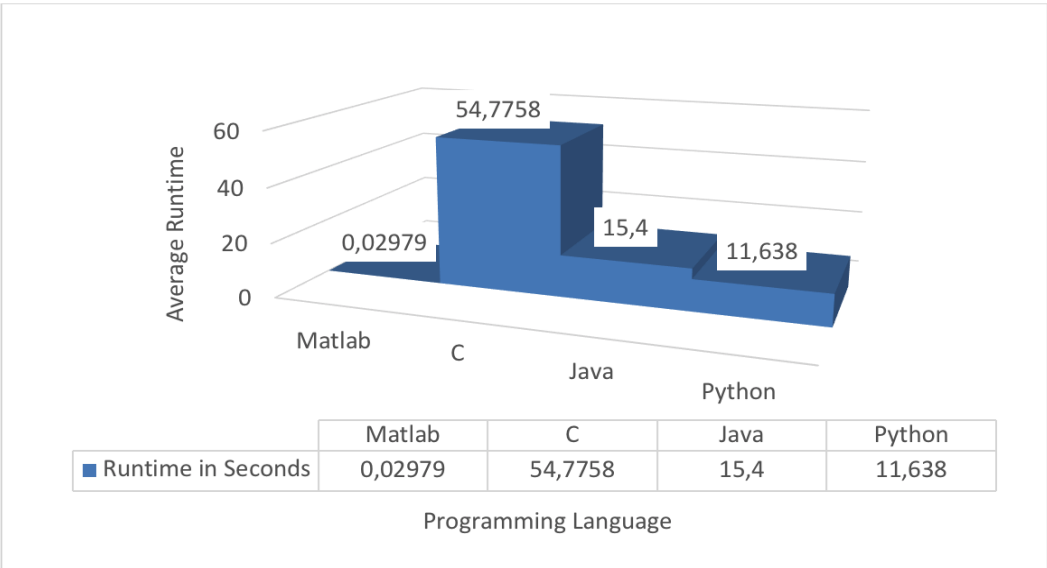

Figure 1: Average runtime in seconds for Fibonacci algorithm

Towers of Hanoi algorithm was also run 5 times for Matlab, C, Python and Java languages on Windows operating system. After the executions, the average results were used. The results for the run times are shown in Table 4 below in seconds.

Table 4: Execution times of programming languages (seconds)

Test Number	MATLAB	C	JAVA	PYTHON
1	29.508920	65.77358	40.0941	3676.294
2	29.049472	65.72233	38.5668	2422.322
3	29.141829	66.33504	37.4843	2619.629
4	28.478471	66.03730	45.3649	2589.791
5	36.911924	67.96224	45.8982	2400.445
Average	30.617	66.36610	41.4816	2741.696

It can be understood from the above results that similar to Fibonacci algorithm, the fastest runtime

for Hanoi is achieved through Matlab programming language with an average of 30.617s. The worst performance belongs to Python programming language with an average runtime of 2742.696s. The below Figure 2 gives a better understanding of the runtime differences between programming languages. There is a vast amount of difference between Matlab and Python. On the other hand, C and Java are close to each other in terms of running performances.

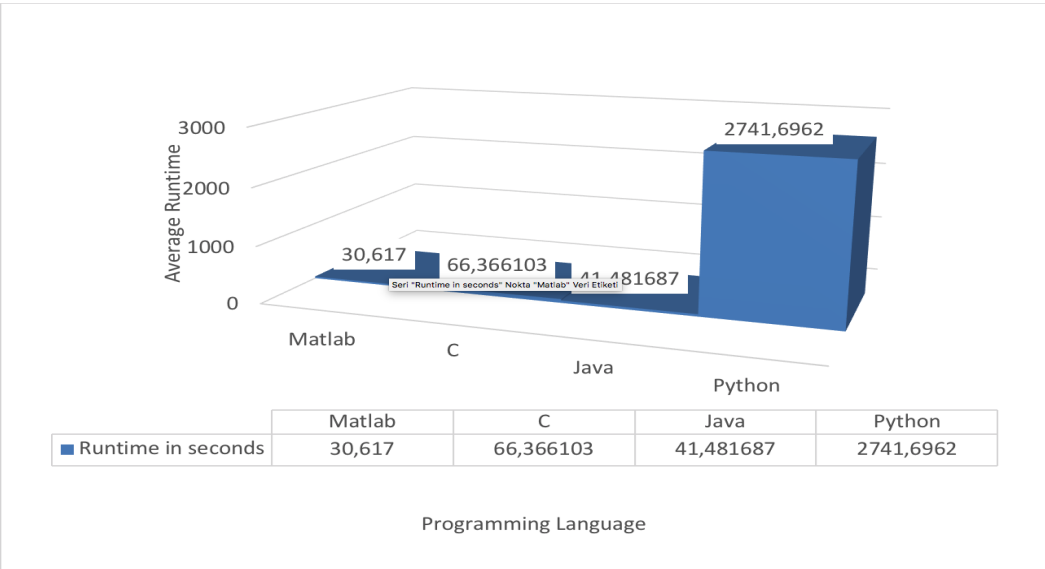

Figure 2: Average runtime in seconds for Towers of Hanoi algorithm

2.3. Code Length

In order to compare the performance of Fibonacci algorithm in programming languages, the line numbers of the code were compared. The results for the code line number and character length information are shown in Table 5.

Table 5: Code lengths of the Fibonacci algorithm

	MATLAB	C	JAVA	PYTHON
Code Length	22	28	39	26
Number of Characters	80	440	686	415

According to the above table, Matlab has the shortest code and the least characters while Java has the longest code and the most characters.

The line numbers of code were also compared for Towers of Hanoi algorithm application and the results for the code line number and character length information are shown in Table 6 below.

Table 6: Code lengths of the Towers of Hanoi algorithm

	MATLAB	C	JAVA	PYTHON
Code Length	16	28	40	17
Number of Characters	469	662	790	443

The above table shows us that Matlab has the shortest code and Python has the least number of characters. However, they are very close to each other. On the other hand, Java has the longest code and the most characters.

3. Results and Conclusions

As a result of this study, it can be concluded that for Fibonacci algorithm, Matlab has the best execution times and C performed the worst. Also, if we look at the code lengths, Matlab has the shortest code length while Java has the longest one. Overall, Matlab has the best performance for implementing Fibonacci algorithm. If we consider these 4 different programming languages for Towers of Hanoi algorithm, we can see similar results. According to the tests, Matlab again performed the best and Python performed the worst. In terms of code lengths, Matlab again shows the best performance because it has the shortest code. In this case, Java shows the worst performance with the longest code and the most characters. The results found in this study show some similarities with Sahin's study. Sahin made 10 different tests including Towers of Hanoi problem for 25 rings using Java, Python and Ruby programming languages and according to his tests, Java has the best performance in terms of execution time and Python takes longer time to execute. Also, Python has less characters and less code length compared to Java and this shows similarity to our study [11]. Biswa, et. al made a study using Bubble Sort algorithm and comparing C, Fortran, C# and Java programming languages [2]. In his tests C# and Java found out to have the best performances for runtimes. Hu, et. al. found similar results with Biswa and recommended Java programming language for engineering applications [10]. Prechelt concluded as a result of his study that the scripting languages, offer reasonable alternatives to C and C++, even for tasks that must handle fair amounts of computation and data [9]. Prechelt's study is in line with our study that the scripting languages are better alternatives and have better performances. Future studies may include other programming languages such as Ruby and C# or use other types of algorithms for comparison.

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